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DE 34 25 104 C2

(54) **Top for an Automotive Sunroof**

The invention relates to a top for an automotive sunroof having a top made of plastic that comprises a plate and at least one molded-on rib on the underside as a single piece. The rib on the top, which is produced by injection molding with the gas assist method, has a hollow space, and the top surface of the plate opposite the rib is formed with no sink marks. The invention also describes a method for producing a plate-like structural component, preferably a top, and a device that is especially suited for this purpose. description

Top for an Automotive Sunroof

Description

The invention concerns a top for an automotive sunroof in accordance with the preamble of claim 1, a method for its manufacture, and a device suitable for this purpose.

A conventional sunroof normally includes a top consisting of one or more sheet metal parts, or if it is to be permeable to light, includes as a top a glass plate with an inner panel fastened to its underside at the edges to accommodate bearings or guides.

In order to save weight and reduce manufacturing costs, the use of plastic tops as a substitute for glass plates or sheet metal tops is known. However, a plastic top requires a reinforcing panel on its underside to lend it the necessary stiffness. An adhesive layer to join such an inner panel to the plastic top must be very flexible in order to compensate for the different coefficients of thermal expansion. This flexibility is achieved at the expense of the stiffness of the top system as a whole. Moreover, the inner panel at least partially negates the weight savings achieved by the plastic top.

Known from DE 34 25 104 C2 is a sunroof for motor vehicles that has a rigid top made of transparent or translucent plastic. In order to provide the top with greater stiffness with respect to thermal and mechanical stresses, plastic reinforcing strips are provided near the edges on the underside of the plate-like top, forming an inseparable unit with the top in a first example embodiment. The reinforcing strips here are composed of a solid rib that runs continuously around the entire bottom edge of the top

piece and is formed as one piece with the top. However, in order to achieve the necessary stiffness for the top, the rib must be designed with significantly larger dimensions than the thickness of the top. Such a solid design of the rib unavoidably results in clearly visible sink marks on the surface of the top as a result of the volume shrinkage of the plastic as it solidifies. Moreover, plastic parts with such a pronounced difference in wall thickness have a strong tendency toward internal stresses and distortion.

In a second example embodiment the reinforcing strips can be made from the same plastic as the top or from a plastic that is compatible with this plastic, so that they can be glued or welded to the top. In this second case, the strips can be embodied as hollow profiles. However, a top with glued-on reinforcing strips or reinforcing profiles requires a great amount of effort to manufacture. Large-area glue joints must be processed, the glue joints must be pretreated with a primer, and the reinforcing profiles must be matched to the shape of the top which may be domed by deformation.

The object of the invention is to create a top for an automotive sunroof that has high inherent stability with light weight and low manufacturing costs. A further object is to specify a method for manufacturing a plate-like structural component, preferably a top of this type, and an apparatus suitable for this purpose.

This object is achieved for the top of the generic type by the features in claim 1. Because the rib is produced by injection molding with the gas assist method, has a hollow space, and the top surface of the plate opposite the rib is formed with no sink marks, this top offers outstanding optical and mechanical performance characteristics

due to its smooth surface and sturdy but nevertheless light (because of their hollowness) reinforcing ribs.

Moreover, a top of this nature is economical to manufacture due to its design as an injection molded plastic part made in the gas assist molding method. The hollow cavity in the reinforcing rib of the top is preferably formed in one step and in the same mold with the top plate. The gas introduced under pressure into the injection mold during manufacture forms a gas bubble which produces the hollow. The pressure in the gas bubble presses the injected plastic against the mold wall as it solidifies, thereby compensating for the volume shrinkage, thus preventing sink marks.

In this way the result is advantageously achieved that only a single molded article need be manufactured and thus no additional manufacturing costs result. Since different materials are not used, no problems arising from differing coefficients of thermal expansion can result, and recycling is easy due to the uniform material.

However, with tops that are light-permeable, which is to say translucent or transparent, the quality achieved with regard to transparency and uniformity of the injection-molded plastic material or the surface can differ from one section to another. With non-transparent tops, these differences can be hidden by painting or dyeing. In contrast, with transparent tops other remedies can be employed.

For this reason, in an advantageous refinement of the invention the conventional gas assist method used to manufacture the top is modified in order to satisfy the stringent requirements for surface quality and optical quality even for amorphous, transparent plastic and when the injection molded part has large dimensions.

The conventional gas assist method and the modified method are compared below.

To manufacture the top according to the invention with the conventional gas assist method, a mold cavity is only partially filled during injection of the plastic melt so that a hollow space can be formed in the reinforcing rib during the subsequent gas injection. The injected melt first fills the cavity of the perimeter rib , since the flow resistance here is lower than in the shallow cavity of the plate because of the cross-section. The plate volume is thus not completely filled with plastic during injection. Nonetheless, the melt is ultimately forced into the plate cavity by the pressure of the gas during gas injection. A number of problems can arise, however. For example, the optical quality can be degraded by different velocities or standstills in parts of the melt front in the plate cavity, by different flow directions, by flow lines where the melt fronts flow into one another, or by air inclusions. Furthermore, incomplete filling of the mold can occur, since variations in the remaining wall thickness in the rib can mean that insufficient material is available to completely fill the plate cavity. Lastly, the possibility cannot be excluded that the hollow in the rib is not completely formed, since an accumulation of material can remain at the place where two gas fronts meet if the mold is already completely filled and the material has no way to escape (since equal gas pressure acts from both sides).

In the modified method, the injection mold according to the invention is designed such that the volume of the mold cavity at the start of the injection process is reduced enough, preferably in the direction of the rib height, that the mold cavity (plate cavity and rib cavity) is completely filled on injection of the same quantity of melt as would be

used in the conventional gas assist method. A more even filling of the mold is achieved in this way, and in particular, uniform filling of the plate cavity is achieved while avoiding the problems and disadvantages discussed above.

At the same time the gas is introduced, the volume of the cavity of the rib is enlarged from the plate toward the rib height in that a corresponding part of the mold, such as an insert piece for example, is moved in a controlled way. The movement is controlled as a function of the injection of the plastic melt and/or the injection of gas. The volume for the cavity produced by the injection of gas is provided by this means, and the cavity formation in the rib can be controlled more reliably and with repeatable precision.

In addition, the plate volume is filled by the normal injection pressure, since only the plastic material in the rib is shaped. Hence, smaller injection forces are sufficient.

An example embodiment of the invention is explained below on the basis of the drawing.

Fig. 1 shows a perspective cross-sectional view of a top produced in accordance with the invention;

Fig. 2 shows a cross-sectional view of a mold with a top produced by the gas assist method;

Fig. 3 shows a cross-sectional view of a mold for a modified gas assist method with a movable insert in the starting position;

Fig. 4 shows a view as in Fig. 3 wherein the movable insert has been moved to increase the volume of a rib cavity;

Fig. 5 shows a cross-sectional view of a mold variant for a modified gas assist method.

Fig. 1 shows a top 1 of an automotive sunroof that has a plate 2 and a perimeter rib 3 on the underside of the plate 2 in the edge region. The guide and mounting parts that attach thereto are not shown. The rib 3 is produced as a single part with the plate 2 using the gas assist method, and has a hollow space 4 created during the injection molding process. The plate 2 (and thus also the rib 3) can consist of a transparent or translucent plastic material when it is to serve as a glass substitute, or otherwise of a non-transparent plastic material.

Fig. 2 shows a simplified, schematic representation of a mold with a bottom mold half 6 and a top mold half 5 for injection molding of the top 1. The mold cavity defined by the two mold halves when the mold is closed consists of a first cavity 7 for the plate 2 and a second cavity 8 for the rib 3 of the top 1. The top 1 is manufactured with this mold using the conventional gas assist method. In this process, enough plastic material for the mass of the finished top is injected into the cavity through at least one injection port 13 in the wall of the bottom mold half under an initially low injection pressure. Due to the larger cross-section, this material initially distributes itself in the shape of a ring in the cavity 8 and the area of cavity 7 immediately above it. Gas under a higher pressure than the injection pressure is then injected through the injection port 13 into the cavity 8, during which process a circumferential, channel-like hollow space 4 forms in the cavity 8 and the plastic material displaced thereby simultaneously forces the material lying above it into the central region of the plate 2 until the latter is fully closed. The gas

pressure in the hollow space 4 is maintained until the plastic material solidifies with a uniform wall thickness.

Fig. 3 shows an injection mold that has been adapted for use in a modified gas assist method. The bottom mold half 6' contains a movable insert 9 that can move back and forth essentially perpendicular to the plate cavity 7' in a guide recess 10, with said insert providing the volume for the rib cavity 8' when it moves away from the plate cavity 7' (downward in Fig. 3). In the top starting position of the insert 9 shown here, a plastic melt is injected at an initially low injection pressure into the plate cavity 7' and the rib cavity 8', whose volume has been reduced to a minimum, until the whole cavity 7', 8' is completely filled. In a first variation, the insert 9 can be moved in a controlled fashion by a piston rod 11 or other known means of force transmission. In this context, the downward motion can be controlled as a function of time, the temperature of the plastic material, or the volume of gas injected into the cavity. In a second, simpler version, the underside of the insert 9 is supported by a compression spring 14 which surrounds the piston rod 11. Said compression spring is preloaded in the starting position such that it resists the low injection pressure when the plastic material is injected and is slowly compressed only by the higher gas injection pressure.

Fig. 4 shows the insert 9 of the mold 5', 6' in its bottom position which provides the full rib volume. The gas injected into rib cavity 8 has formed the hollow space 4 in the rib 3. The surface section 12 of the plate 2 opposite the rib 3 is formed without sink marks since the gas pressure in the hollow space 4 is maintained until complete solidification of the plastic melt, compensating for the shrinkage of the plastic material.

In another advantageous embodiment shown in Fig. 5, a bottom mold half 25 has an offset two-part guide recess whose top part 30A accommodates an insert 29 whose top surface defines a flexible cavity 28 when the insert 29 is moved to form a rib (not shown) analogous to the rib labeled 3 in Fig. 1. The bottom surface of the insert 29 is supported by a piston 31A with a relatively large diameter, which in turn is guided coaxially to the insert 29 in a bottom part 30B of the guide recess.

The bottom part 30B of the guide recess forms the side walls of a pressure chamber 32, which can be connected in alternation through a pressure line 33 and a multidirectional valve 34 to a pressure source 35 or to an exhaust line 37 equipped with an adjustable throttle valve 36. In the first switching position of the multidirectional valve 34, as shown in Fig. 5, the pressure chamber 32 is connected to the pressure source 35, with the piston 31A pushing the insert 29 into its top starting position. In this position, a second pressure line 38, which is arranged in the bottom mold part 25 and terminates by way of a check valve 39 in an injection line 40 for the plastic material, is connected to an exhaust line 41. In this position, the plastic material is introduced into the mold cavity. When the material has been completely injected into the mold, the multidirectional valve 34 switches to its second switching position in which the pressure line 33 is connected to the throttled exhaust line 37 and in which the pressure line 38 is simultaneously connected to the pressure source 35, thus supplying compressed air to the mold cavity through the check valve 35. While the hollow space forms in the rib cavity 28, the insert 29 slowly moves downward. After the hollow space 4 in the rib 3 has formed in the rib cavity 28 and the top is sufficiently stable due to cooling, the mold is opened. The top can be ejected at its edges either through another brief application of

pressure to the pressure chamber 32, where the insert 29 is moved back upward to its starting position, or in an alternative, it is ejected mechanically through an upward pressure applied to the elongated shaft of the piston 31 projecting downward out of the bottom mold half 25.

In an alternative embodiment, a finished plastic plate is placed in the mold and the hollow reinforcing rib is then injection molded onto it using the gas assist method. Particularly for smaller production quantities, such molding on of the rib to a cut and hot-formed plate is more cost-effective.

Claims

1. Top for an automotive sunroof, wherein the top is made of plastic and comprises a plate and at least one molded-on rib on its underside as a single piece, **characterized in that** the rib (3), which is produced by injection molding with the gas assist method, of the top (1) has a hollow space (4), and the top surface of the plate (2) opposite the rib (3) is formed with no sink marks.

2. Top from claim 1, **characterized in that** the plastic of which the top (1) is made is an amorphous, transparent or translucent plastic.

3. Top from claim 1 or 2, **characterized in that** the rib (3) of the top (1) is designed to extend around the circumference near the edge of the plate (2).

4. Method for producing a plate-like structural component, preferably a top for an automotive sunroof, wherein the top is made of plastic and comprises a plate and a molded-on rib on the underside thereof, **characterized in that** the top is injection molded with the gas assist method, wherein first a mold cavity in the rib region is partially filled with plastic melt, then a hollow space is produced in the rib through the injection of gas into the rib region of the mold cavity, whereupon the plastic melt fills the mold cavity for the plate due to the gas pressure of the gas injection, and wherein finally the gas pressure is maintained until the plastic

melt has solidified sufficiently that the surface of the plate is formed with no sink marks in the rib region.

5. Method for producing a plate-like structural component, preferably a top for an automotive sunroof, wherein the top is made of plastic and comprises a plate and a molded-on rib on the underside thereof, **characterized in that** the top is injection molded in a modified gas assist method using a mold with a movable insert to vary the volume of the mold cavity, wherein first a volume of the mold cavity reduced by the movable insert is filled with plastic melt, and then a hollow space is created in the rib by gas injection in the rib region of the mold cavity, wherein the movable insert is simultaneously moved to enlarge the volume of the mold cavity in the rib region, and wherein finally the gas pressure is maintained until the plastic melt has solidified sufficiently that the surface of the plate is formed with no sink marks in the rib region.

6. Method from claim 5, **characterized in that** the movable insert is moved in the direction of the rib height to vary the volume of the rib cavity.

7. Method from claim 5 or 6, **characterized in that** the motion of the movable insert (9) is controllable as a function of the injection of the plastic melt and/or of the gas injection.

8. Device for carrying out the method from one of claims 5 – 7, **characterized by** a mold comprising a top mold half (5) and a bottom mold half (6) whose mold halves (5 and 6) when the mold is closed define a first cavity (7) for formation of the plate (2) and a second cavity connected thereto for formation of the rib (3), having an insert (9) that defines the underside of the rib (3) and is movably supported in the bottom mold half (6).

9. Device from claim 8, **characterized in that** the insert (9) can move against the pressure of a spring (compression spring 14).

10. Device from claim 8, **characterized in that** the insert (9) can move against the pressure of a gas cushion whose exhaust is throttled.

11. Device from one of claims 8 – 10, **characterized in that** the insert (9) serves as an ejector with a force applied to the underside of the rib (3) when the form is open.

Herewith 3 sheet(s) of drawings
